Harmonization Frameworks for Net-Ready Sensors

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Summer Workshop on Net-Ready Sensors

Mallikarjun Shankar, PhD
shankarm@ornl.gov
Computational Science and Engineering Division
Oak Ridge National Laboratory

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Outline

- Sensor Networks and Net-readiness
  - Source of lessons learned
- Addressing Harmonization
  - Separating concerns
  - Understanding each axis of harmonization
- Moving Towards Net-ready Sensors
  - Making net-readiness ubiquitous - concept demonstration

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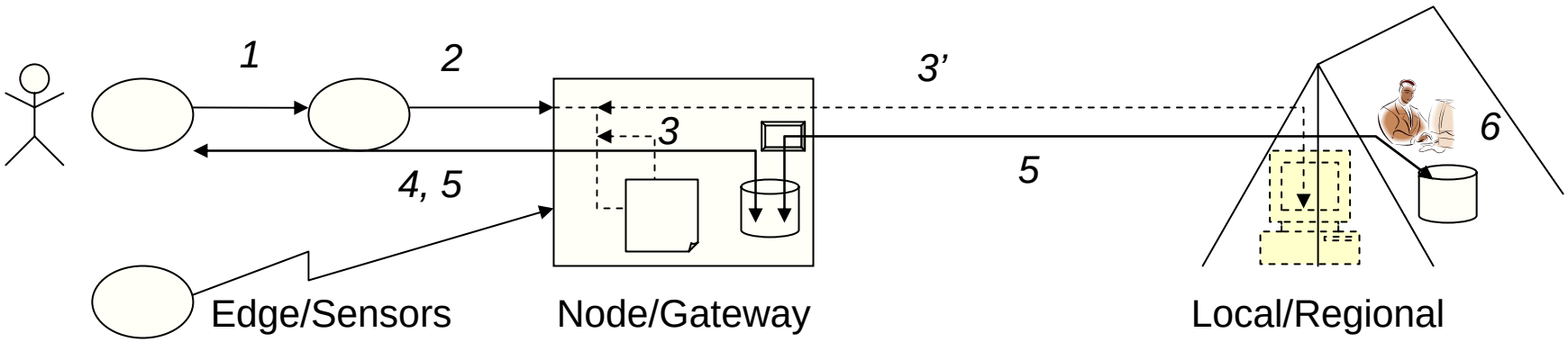
Sample Net-Ready Sensor Networks Flow



Application - Session	HTTP
Transport	TCP
Link/Network	IP
Physical	802.X, 1451, USB

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Sensor networks raise both infrastructure and data interoperability concerns

What Might Constitute the Components of a Net-Centric Framework for Sensor Networks?

Standards-based networks

Network Services

Physical Interfaces

Network

Data Formats And Schemas

Services
Discovery
Security
Collaboration
Metadata
Management
Mediation
Policy
Publish
Subscribe

Application Interfaces

911 Dispatch

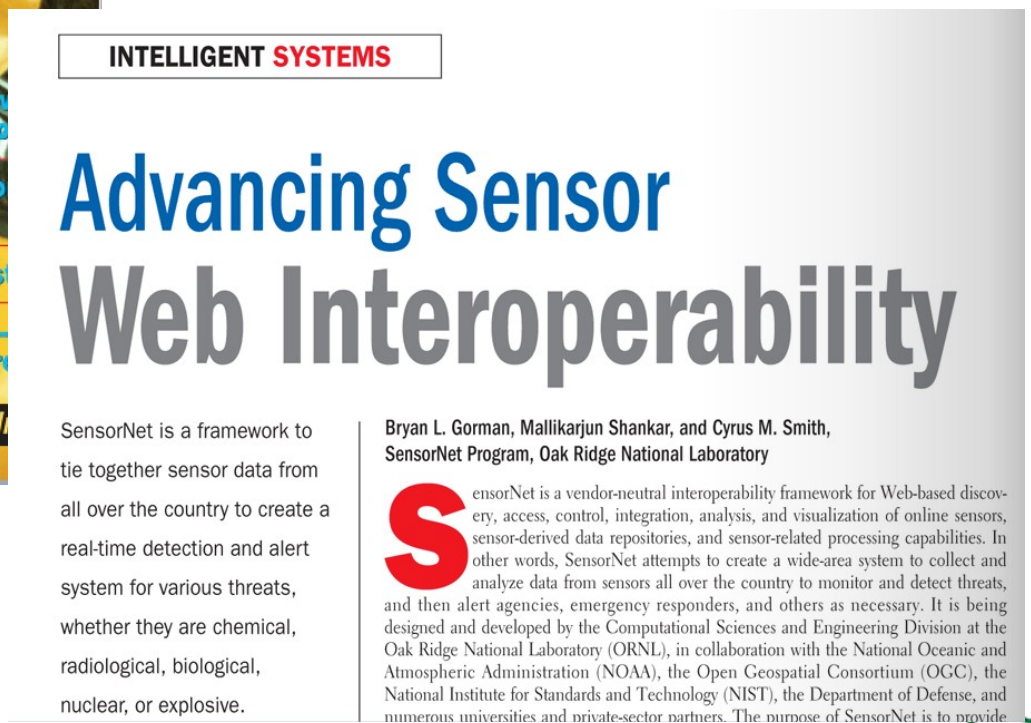
Analysis, Modeling, and Prediction

A plug-and-play standard for self-identifying devices

Domain-specific standards for data formats

A Common Application Programming Interface

A Framework for Wide-Area Interoperable Sensor Networks


INTELLIGENT SYSTEMS

Advancing Sensor Web Interoperability

SensorNet is a framework to tie together sensor data from all over the country to create a real-time detection and alert system for various threats, whether they are chemical, radiological, biological, nuclear, or explosive.

Bryan L. Gorman, Mallikarjun Shankar, and Cyrus M. Smith,
SensorNet Program, Oak Ridge National Laboratory

SensorNet is a vendor-neutral interoperability framework for Web-based discovery, access, control, integration, analysis, and visualization of online sensors, sensor-derived data repositories, and sensor-related processing capabilities. In other words, SensorNet attempts to create a wide-area system to collect and analyze data from sensors all over the country to monitor and detect threats, and then alert agencies, emergency responders, and others as necessary. It is being designed and developed by the Computational Sciences and Engineering Division at the Oak Ridge National Laboratory (ORNL), in collaboration with the National Oceanic and Atmospheric Administration (NOAA), the Open Geospatial Consortium (OGC), the National Institute for Standards and Technology (NIST), the Department of Defense, and numerous universities and private-sector partners. The purpose of SensorNet is to provide

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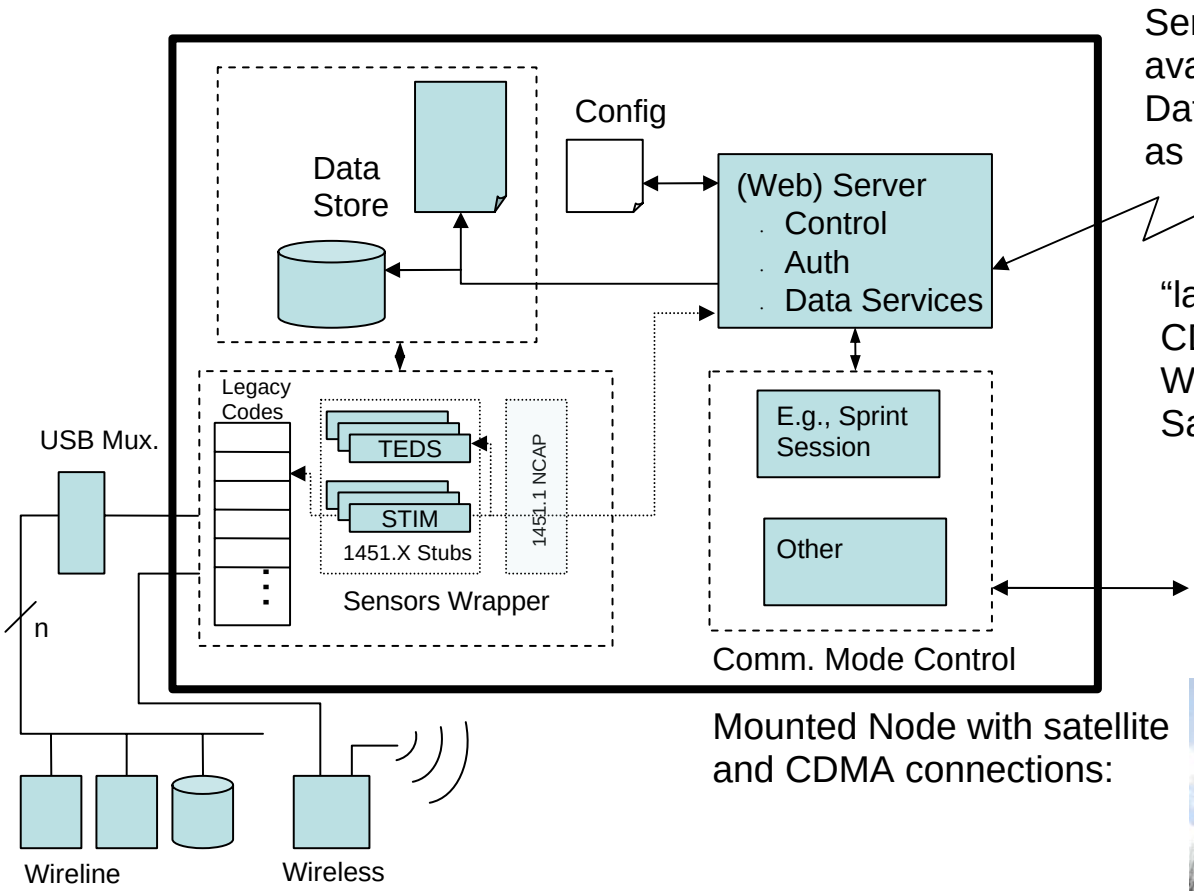
SensorNet Edge – Prototype Node



Services are available to Regional Data Centers as well as external users

"last-mile" link on CDMA, Ethernet, Wireless LANS, MANS, Satellite, etc.

Mounted Node with satellite and CDMA connections:

Sensors: CBRNE + Weather + Image + ...

The SensorNet Framework

- Standards-based
- Competing commercial implementations in use
  - Several commercial vendors and several PD versions of WFS
  - Systems Integrators are supporting WFS implementations
  - Commercial vendors are providing us Nodes /proxy devices to requirements
- Several deployments already in service or planned for near future
  - Completed 3 years of 5 year program at Ft. Bragg
  - Port of Memphis
  - Weigh Stations in three states
  - Mobile (deployable) systems
  - Military District of Washington
  - Port of Charleston

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Commercializing the SensorNet Framework at Fort Bragg

ORACLE Database

INTERGRAPH 911 CAD

In Situ and Mobile 3rd Party Applications

INTERGRAPH 911 Communications Server

Mass Notification Systems

3e Technologies International

(IEEE 1451 proxy services)

(OGC Sensor Alert Service)

coversant

(OGC Web Feature Services)

galdos systems inc

DoD Net-Centric Enterprise Services Framework

Lowery/CCIS Access Control

NOAA and Smiths Sensors

Honeywell and Monaco Fire Alarms

CheckPoint Duress and Intrusion Alarms

ObjectVideo Intelligent Video Surveillance

A Systematic Approach to Standards Harmonization

CBRN, N42.42, CAP, EDXL, WFS, SICoP, XMPP, JCID, SWE, 1451, UPnP, SPOT, E911, ..

- Interrogative approach – a useful couplet:

> *My faithful friends have over time helped lighten up my brow*
> *None more than why and what and which, and when and where and how*

- Consider the above as dimensions of analysis to develop a framework for harmonization
- Each dimension has sub-concerns

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Why Harmonization?

- Ebb-and-flow of subcomponents forces standards variation, reinvention, and consequent mismatches
  - New devices
  - New techniques
  - Continuous refinement
- A one-stop over-arching solution works locally and could be challenged over time by focused, efficient solutions

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What to Harmonize?

The nice thing about standards is that there are so many of them to choose from.
- Andrew S. Tanenbaum

	DoD	DHS	NIST	OASIS	OGC	DOT
Activity	JPEO-CBD	Standards Portfolio S&T Directorate	Sensor Interface Standards	Emergency Interoperability Consortium	Sensor Web Enablement	Incident Management
Standards	JPM-IS Data CBRN Common Data Model NATO NBC Standards (Allied Tactical Publication 45B) STANAG 5523	ANSI N42.32 ANSI N42.33 ANSI N42.34 ANSI N42.35 ANSI N42.38 ANSI N42.42 ASTM E54 AOAC International	IEEE 1451.0 IEEE 1451.1 IEEE 1451.2 IEEE 1451.3 IEEE 1451.4 IEEE 1451.5 IEEE 1451.6	Common Alerting Protocol Emergency Data Exchange Language WSN WSA	Sensor Observation Service Sensor Planning Service Sensor Alerting Service Geospatial Markup Language Web Feature Service	IEEE Std 1512.3-2002 (HAZMAT Standard)

What to Harmonize (contd.)?

- Delineate Functionality
  - Data: E.g., unify data models
  - Control
    - Events and alerting: E.g., systematize alert levels and semantics
    - Actuation: E.g., develop common language for control signals
  - Management: E.g., identify similar MIBs (management information bases)
- Operational Components
  - Software: Protocol, Fields, Description
  - Hardware: Components, Interfaces, Quality

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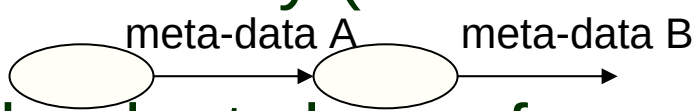
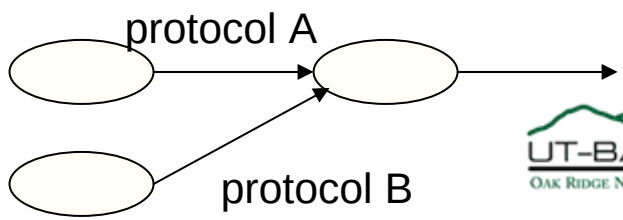
Which Standards to Choose?

- Consequence of “What”
  - Examples:
    - Sensors Meta-data - IEEE 1451 and SensorML
    - Alerting candidates - Sensor Alerting Service and Web Notification Service. As the data leaves the regional system, it needs to map to CAP and EDXL.
  - Classic due-diligence:
    - Lean toward mature standards: finite market share
    - Lean toward a niche idea
- Part of an end-to-end chain of activity (linear dependence)
- Part of a multifunction or redundant chain of activity (parallel operation)





Where do you Locate Harmonization?

- Sensor Data at the Edge
  - Smart sensor physical interfaces
  - Edge-based local services
- Edge to Middleware Services
  - Local (NCAP-compatible) applications
  - Harmonize with spatio-temporal “web” services and protocols
- Application-level interoperation
  - Schema adoption from standards group such as ANSI N42.42, GML-Profile, etc.

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When do you Harmonize?

- At Design Time
  - Define the role of certain structures in the system design that will be easy to bring together
  - Choose certain standards that interoperate
- At Implementation and Run-Time
  - Include translators
  - Develop network centric structure
  - Deployment/Run time: late-binding of data- and process- elements

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A Possible Explanation for Network-Centricity's Attraction

- Software module interoperability has been a historic challenge: C, C++, Java, ..
- Mitigated by IDL (Interface Definition Languages) – but the same IDL may be compiled into two languages
- Modules compiled into different languages can work over a network (e.g., CORBA used protocols such as IIOP)
- Separation of producer-consumer cleans up the interaction
- The network is a clarifier and a simplifier!

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How do you Harmonize? Policy: Treat Harmonization as an Architectural Goal

- Design for network interoperability and thereby mitigate harmonization hurdles
- Identify dimensions of harmonization in the system to achieve separation of (design and implementation) concerns
- Enforce reuse (early and often – for each subcomponent). Perform:
  - Functional analysis (and background search)
  - Engineering trade-offs study
  - Community acceptance estimation
  - General applicability analysis

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How do you Harmonize? Mechanism

- Implementation Mechanism
  - Words – Define and map vocabulary, syntax
  - Protocol – Design and develop translators, wrappers, and services modules
  - Semantics – Mandate ontologies and conceptual schema representations
- Choose a Net-centric Model
  - Define an interface for exchange, e.g., a web-service
  - Use translators as a stepping stone – they are not all bad – a dictionary for multiple languages is an ontology that tells how terms depend on each other

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N42.42 Schema (ANSI) with GML Representations

Type Name (ANSI)	ANSI use	SNET use
doubleUnc		
	ItemQuantity	(gml:QuantityPropertyType)
	NuclideActivity	activity
	Calibration/Array2D/Point2D/X	CalibrationPoint/x
	Calibration/Array2D/Point2D/Y	CalibrationPoint/y
durationUnc		
coordinateList		
	MeasurementLocation	gml:location/
booleanList		
	Alarmed	alarms
....		

N42 Field	SensorNet Application Schema Field
N42InstrumentData/Measurement	snet:Observation
N42InstrumentData/Measurement/@UUID	snet:Observation/gml:id
N42InstrumentData/Measurement/InstrumentInformation	None (handled by n42:Sensor)
N42InstrumentData/Measurement/InstrumentInformation/InstrumentType	n42:N42Sensor /n42:sensorType
N42InstrumentData/Measurement/InstrumentInformation/Manufacturer	snet:Sensor/snet:dataSourceManufacturer
N42InstrumentData/Measurement/InstrumentInformation/InstrumentModel	snet:Sensor/snet:dataSourceModel
.....	

Data-types and Application Schema Map

Sample Information Entities in IEEE 1451 and OGC SWE: A Manual Mapping Process Currently

TEDS Type	Presence	Scope
Meta TEDS	Mandatory	TIM
Transducer channel TEDS	Mandatory	Channel
User's transducer name TEDS	Mandatory	TIM or Channel
PHY TEDS	Mandatory	TIM
Calibration TEDS	Optional	Channel
Frequency response TEDS	Optional	Channel
Transfer function TEDS	Optional	Channel
End user application specific TEDS	Optional	TIM or Channel
Manufacturer Defined TEDS	Optional	TIM or Channel
Identification TEDS (text based)	Optional	TIM or Channel
Location TEDS (text based)	Optional	TIM
Command TEDS (text based)	Optional	TIM

Category Types in SensorML and SWE
Platform
Process
Sensor
Identifier
Phenomenon
Observable
MeasurementCapabilities
Dynamic Range
Accuracy
Component
Results and ResultMeasurement
Procedure

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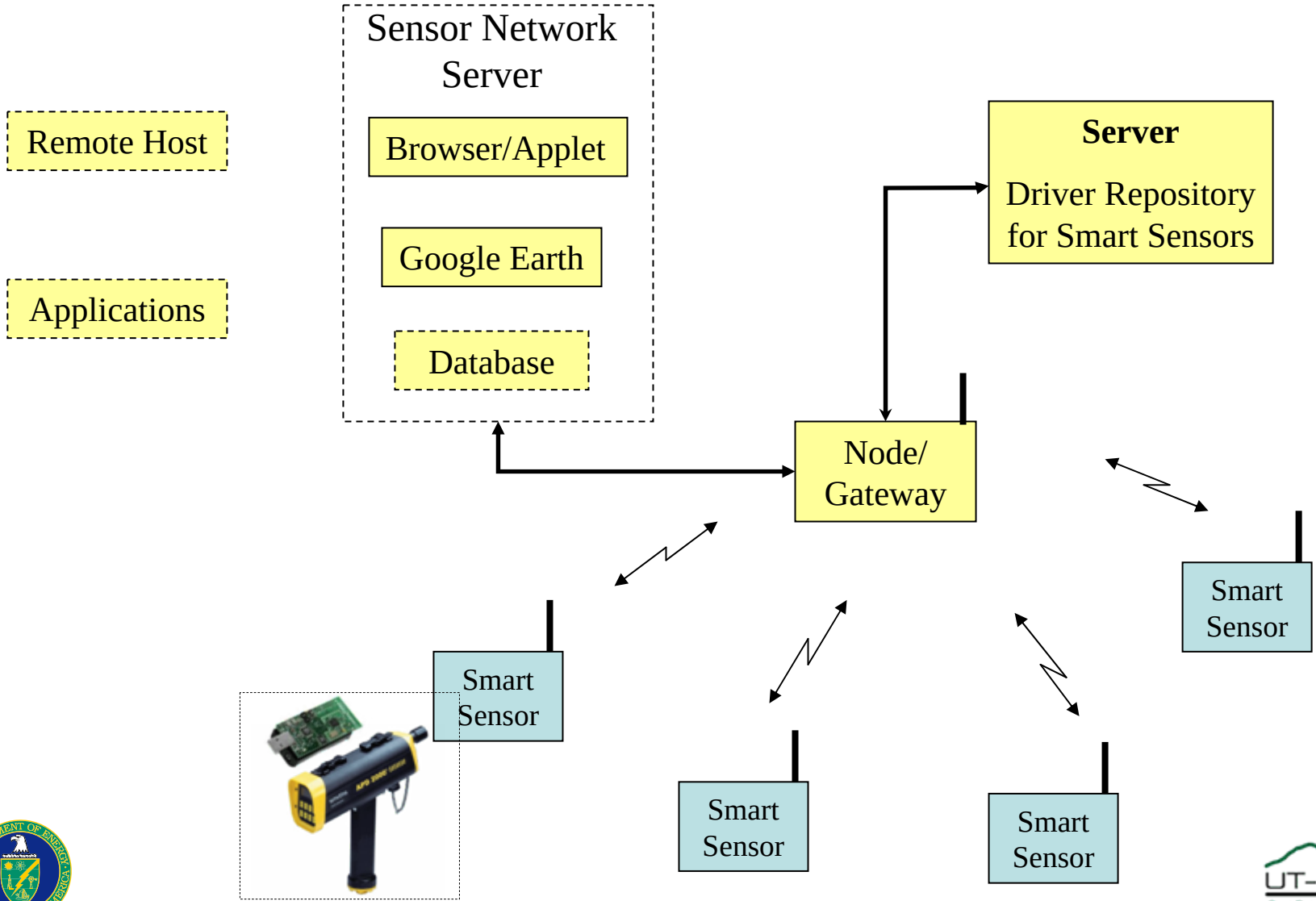
Example Net-Ready Sensor Network System



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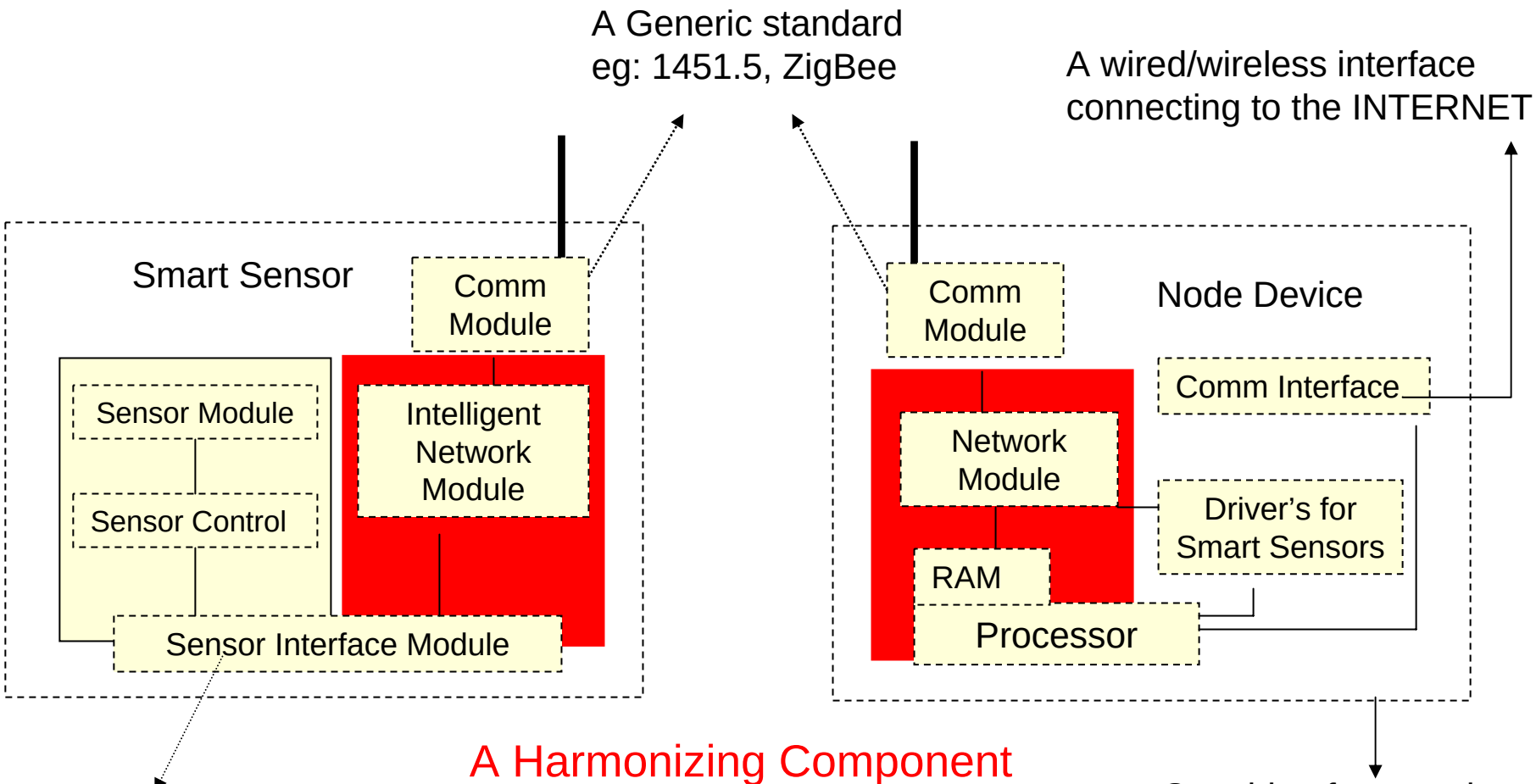

Summary

- Systems development will inevitably involve a wide variety of standards
- Harmonizing them will be a recurring objective
- Sensor networks will require harmonization of both infrastructure and data standards
- Focused interoperability is a road forward
- Address harmonization by
  - Identifying dimensions of interoperation
  - Choosing a network-centric model of interaction

-- Thank You --